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CLASSROOM METHODS AND DEVICES

PRACTICAL LESSONS IN ELECTRICITY FOR THE SIXTH AND SEVENTH GRADES

In the Elementary School of the School of Education many physical science topics are introduced in the natural history work, beginning definitely with a study of magnetism and electricity in the latter part of the sixth grade, and continuing these and other science topics in the seventh grade.

The work is presented in class as a series of problems which the children are led to solve, mainly by individual experimentation. Much of the apparatus used is made by the pupils, some is made by the teacher, and a small amount of it is purchased. Apparatus, therefore, is nearly all of the simple home-made type, intricate apparatus being avoided. From their own efforts and this home-made apparatus the children obtain results and get a clearer knowledge of the subject; also they acquire efficiency in constructive work, and at the same time develop the powers of observation and reasoning. No textbook is used, but notebooks are compiled in which diagrams are made and descriptions of the work the pupils have done are written.

Following are a few typical studies in electricity:

LESSONS ON THE ELECTRIC BELL AND THE BUZZER

Problem 1: What is the difference, in construction, between the bell and the buzzer?

Have pupils examine both carefully and they will learn soon that the only difference is that the bell has a gong and a long hammer while the buzzer has a short hammer and no gong.

Problem 2: What are the different parts of the bell or the buzzer?

The pupils, with bell or buzzer in hand, are asked in turn to point out one thing which they see, and if the correct name is not known to them, it is given by the teacher. A large diagram is put on the board by teacher or pupil, and the parts labeled and learned: Binding-posts *BP;* coils of wire *C;* connecting bar of iron holding the coils at one end *CB;* hammer placed across the other end of coils but not touching them *H;* small spring on hammers, one end of which rests against the connecting point of a small arm *A;* this arm, *A*, with connecting point, insulated (i.e., separated by rubber or other non-conducting material) from base *B;* rubber tube covering parts of the wire; insulation or non-conducting pad under one of the binding-posts; and gong *G*.

Pupils draw diagram of bell or buzzer in notebook and label parts. See Fig. 1.

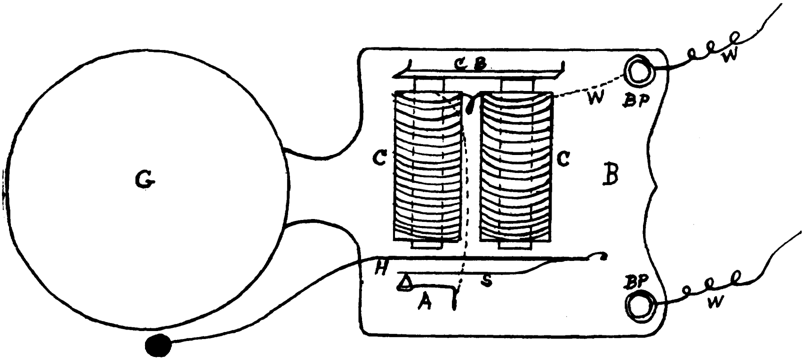

Fig. 1.—Electric Bell

Before learning how a bell or a buzzer works, or tracing the path of electric current through it, it is best to have the pupils make a cell and learn how to attach it to the bell so that the bell will ring.

Problem 3: How can a cell be made which will give sufficient electric current to ring a bell?

a) Pupils take an eight-ounce bottle, or pint fruit jar, and put into it 1 cup of water, 1 teaspoonful of potassium bichromate, and, always last, one-eighth of a cup, or 5 teaspoonfuls, of strong sulphuric acid. (The teacher had better measure and pour in the acid to avoid danger of burning hands or clothing.) A carbon rod and a zinc rod or strip, each from 4 to 6 inches long, are needed for the cell. The carbon is the kind used in arc lights and stereopticon lanterns, and may be purchased for a few cents, or taken from worn-out dry cells. Zinc rods or strips are inexpensive, and may be purchased from an electric or hardware store. For convenience the pupils fasten the two rods together with rubber bands in such a way that they do not touch each other. Next they attach one bare end of a copper wire, size No. 18 to No. 24, to the top of the carbon rod, and a second wire to the zinc rod, and connect the other ends of the wires to the binding-posts of the bell. Last of all the rods are put into the cell. See Fig. 2.

If the bell does not ring at once, vibrate or start the hammer with the finger.

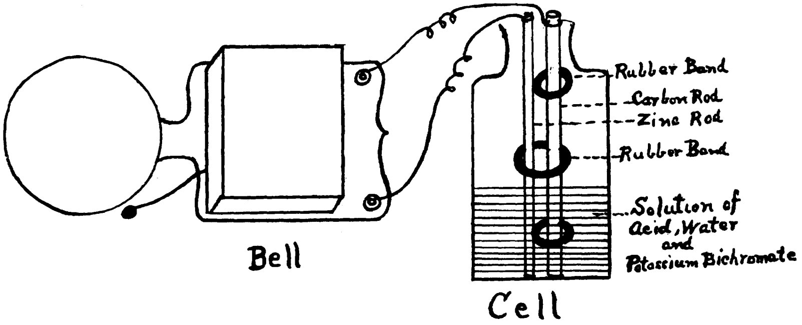

FIG. 2

b) Cautions in using this cell (called the Grenêt or Bichromate cell):

1. Handle bottle carefully so as not to spill acid solution. Better fasten it into ring stand.

2. Make all connections before putting the rods into the cell. Have connections tightly made, with ends of wires bare and clean.

3. Remove rods from cell when it is not in use, to prevent the acid from eating away the zinc rod.

Problem 4: Trace the path of the electric current through the bell.

Pupils easily follow the wire from one binding-post of the cell to the bell, thence to the nearer coil, then to the second coil, and from that coil to the little arm whose contact point rests against the spring on the hammer. They may be able to see how the current now passes through the contact point to the spring on the hammer, thence through the hammer, from the hammer to the iron base, through the base to the second binding-post, thence through the second wire to the cell again.

Questions bring out the fact that the current cannot go through the bell base to the first binding-post because this binding-post is insulated from the base.

Problem 5: What makes the buzzer or the bell ring when an electric current goes through it?

A horseshoe magnet, such as is familiar to children, may be shown and its power to attract iron illustrated. Then a large round nail, or some other piece of iron, may be tested to see if it has magnetism and will draw iron (tacks, for example) to it. If not (and it will not unless previously magnetized), wind covered copper wire around it, connect the wire to a cell, and send a current around the nail. Test it while the current is on. Does it now pick up tacks or other iron?

Notice that the coils on the bell, with the bar of iron connecting them, resemble a horseshoe magnet with wires wound around each arm.

Will these coils attract tacks when a current runs through the wire around them? Try it.

What effect will this attracting force have on the hammer?

What prevents the hammer from being drawn to the ends of the coils and sticking there?

When the hammer is drawn away from the contact point of the little arm, is the electric current affected?

If the current is broken, do the coils remain magnetized?

When the hammer is pulled back by the spring at one end of it, to the contact point, does the electric current flow through the bell and coils again?

Now it is seen that the bell is made to ring by quickly breaking and making again the electric circuit at the contact point, thus magnetizing and demagnetizing the coils, alternately attracting and releasing the hammer.

Applications of the bell: Door bells, school bells, fire alarm bells, call bells, etc.

Applications of the cell: Ringing bells, running electric toys, telephones, furnishing spark for gasoline engines, etc.

LESSON ON THE PUSH BUTTON

As it injures most cells to run them continuously, a push button is needed so that the current may be turned off or on at will.

Problem 6: How may a simple push button be made?

Allow pupils to examine an ordinary push button, which may be purchased for ten cents, learning parts and connecting it in with bell and cell. Raise questions as to the principle involved, etc. It is seen that when the two pieces of metal in the push button are pressed together, the electric current passes through the wires which are attached to the two pieces of metal and thence to the bell and cell, thus completing the circuit. Next have the children draw a plan of a simple push button which they would like to make. Then give them a block of wood, two pieces of metal, a hammer, small nails, and tacks, and allow them to carry out their plan. See push button in Fig. 4.

Connect the home-made push button with bell and cell and work it. Keep for future use in school or at home.

LESSONS ON ELECTROPLATING

While the pupil's cell is still in good condition, it is well to give one or two lessons in simple electroplating. Copper plating can be done by the pupils with simple apparatus which they can put together.

Problem 7: How can a cell be used to copper plate something?

a) Pupils put a few crystals of copper sulphate (blue vitriol) in a metal dish with one-half a glass of water and heat to dissolve the crystals. Dilute to a faint-blue solution.

b) Let each fill a glass one-half full of this solution and put into it a narrow strip of copper and the object to be plated, after first attaching copper wires to each of them. Attach the other end of the wire which is on the copper strip to the carbon rod of the cell, and the second wire to the zinc of the cell. Within five or ten minutes the article being plated will show the reddish tinge of the copper. Preferably use first a piece of carbon rod to plate, then try other things, such as clean pieces of iron, steel, etc. See Fig. 3.

Problem 8: How can the plating be removed by electricity?

Try suggestions of the pupils, or lead them to reverse the connections so that the copper strip is attached to the zinc rod of the cell, thus reversing the direction of the current.

In discussions bring out the fact that all electroplating is done on this principle: nickel plating requires a certain nickel solution and a lump of nickel, or a nickel strip, instead of a copper solution and a copper strip; silver and gold plating require silver and gold solutions, and silver and gold strips respectively.

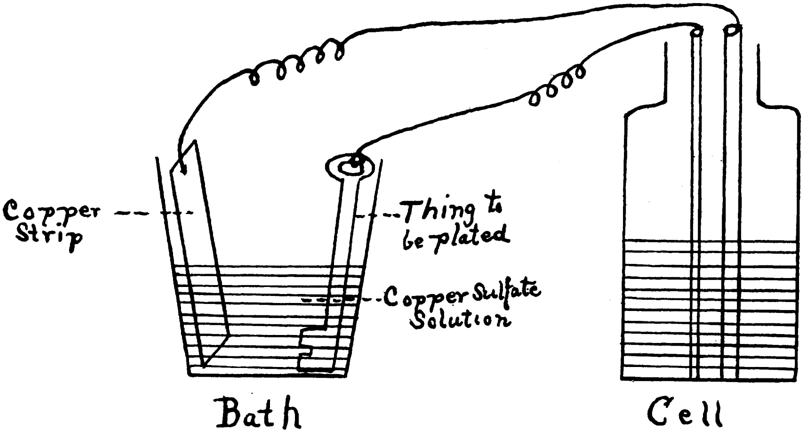

FIG. 3.—Electroplating

LESSONS ON THE GALVANOSCOPE

After the cell has been made and something has been learned about an electric current in its power to ring bells and do copper plating, another interesting problem is to make a simple apparatus to determine whether a cell has any electricity in it, and if so in what direction it flows through the wires. Also the apparatus will show whether the current is very weak or strong.

Problem 9: To make a piece of apparatus called a galvanoscope, that will detect a current given by a cell.

a) Pupils are given the general idea that a block of wood needs to be wound with a few coils of wire in such a way that a compass may be placed on the block directly under the wires. Sometimes a hole is bored in the block, in which the compass is placed. Again, small strips of wood are nailed to one surface of the block and the compass placed between them and under the wires. The children may devise other ways of getting the same results. See Fig. 4.

b) Pupils connect up the galvanoscope with the cell and the push button. Place the galvanoscope so that the wires run north and south, parallel to the compass needle, and press push button, watching the compass needle.

Does the north end of the compass needle move toward the east or the west? How far? Sharply to the east or west, or only part way?

Does it swing to the north again when the current is off?

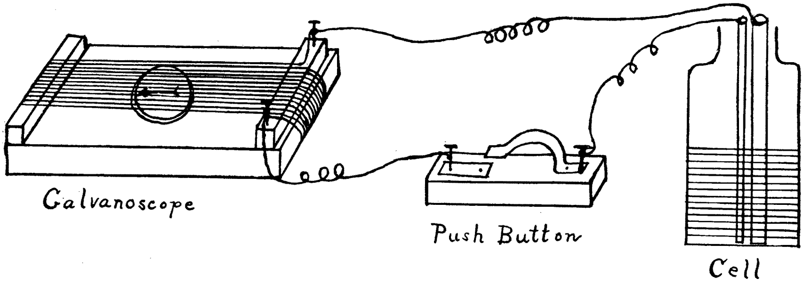

FIG. 4

This proves that the cell sends a current through the wire, and denotes somewhat its strength. If the current is weak the needle moves but slightly.

Problem 10: How can the direction of the current be determined by the galvanoscope?

Pupils put right hand over the compass, palm down, with thumb extended at right angles to the fingers, and so place the hand that the thumb points to the east if the north end of the needle points that way when the current is on, or toward the west if the compass points that way; then the extended fingers will point the direction the current is flowing in the wire.

Reverse the current in the wires by changing connections. For example, exchange ends of wires on copper and zinc rods of the cell. Does this alter the direction of the needle?

Problem 11: Does a stronger current through the wire affect the compass more strongly?

Pupils either connect two cells to the galvanoscope (connect the carbon rod of one cell with the zinc rod in the second cell), or have one strong cell. Turn on current and test compass. Result?

Problem 12: Do more turns of wire around the galvanoscope or a less number of turns affect the compass needle?

Pupils add more wire around the block and test the compass. Try only two or three turns of wire. Results?

LESSONS ON MAGNETIC FIELDS, OR MAGNETIC INFLUENCE

The question which naturally arises now is, How is it that the compass is affected when it is near wires which have a current running through them? Beginning with the magnetic field, or influence, of a bar magnet, the child can easily be taught that there is magnetic influence surrounding an electric current in wires.

Problem 13: How is it that a current in a wire is able to affect a compass placed near it?

If pupils have studied magnets, they understand what a magnetic field, or magnetic influence, about the magnet means. This influence is best shown by placing a magnet under a sheet of cardboard and sprinkling iron filings on the cardboard. If one gently taps the cardboard, the filings arrange themselves in curves about the magnet, thus outlining the magnetic field. If children have not studied magnets, have them perform this experiment.

The same magnetic influence may be shown to exist around a wire through which a current flows. Wind some covered wire in a rectangular loop, ten or fifteen turns, and place it in a slit in a sheet of cardboard so that one-half of the coil is above and the rest below the cardboard. Have two holes at proper distances along the slit so that the coils of wire will fit in, allowing the slit to close up.

Attach the ends of the wire to the home-made cell and the push button. Sprinkle some iron filings on the cardboard about the wires, then turn on the current and gently tap the cardboard. The filings will form concentric circles about the wires, showing the magnetic influence. See Fig. 5.

Place a small compass near the wire and turn on the current. Does the needle of the compass arrange itself parallel to the lines of magnetic influence or force? Move the compass along these lines around the wires. How does it behave?

Shut off the current; does the needle resume the north-and-south direction? Repeat.

Move the compass around the second coil of wire. Does the needle point in the same direction as when near the first wires, or in the opposite direction?

Does the magnetic field run around the two wires in the same direction?

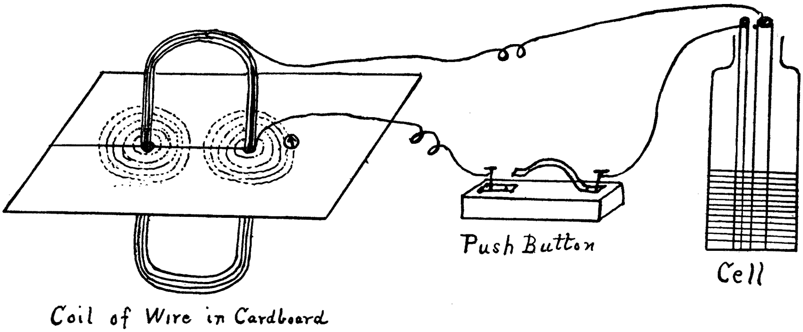

FIG. 5

Does the direction the current takes through the wires have any effect on the direction of the magnetic field?

Can you see now how the current in the galvanoscope wires affects the compass and makes it point at right angles to the direction of the wires?

LESSON ON THE SOLENOID

Having seen that a magnetic field exists around a wire whenever a current passes through it, we next make a magnet out of a coiled wire.

Problem 14: How may a magnet be made out of a coil of wire?

Pupils take a piece of covered wire about three feet long and wind it in a close coil around a pencil or large round nail, leaving

6 or 8 inches of each end of the wire unwound. See Fig. 6. Slip the coil off the pencil and attach it to push button and cell.

Put one end of the coil as near as possible to one end of the compass needle and turn on current. Is the needle affected?

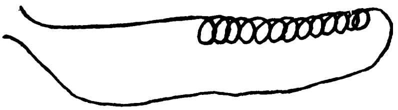

FIG. 6.—Solenoid

Try the other end of the coil near the compass. Is the effect different? Has the coil a north and a south pole?

Put one end of the coil on some iron filings. Do they adhere to the coil? Try the other end. Result?

The coil of wire with a current passing through it is called a solenoid, and it has a north and a south pole like a magnet, though it is very weak.

LESSONS ON THE ELECTROMAGNET

Problem 15: How can the solenoid be made into an electromagnet?

Allow pupils to put an iron nail, or other soft iron, through the solenoid which is attached to the cell and push button, first testing the nail in iron filings or with the compass to see that it has no magnetism in it, or but very little.

Now put one end of the nail, which is in the coil, into iron filings and turn on the current. Result?

Do many filings adhere to the nail when it is raised?

Does anything happen if the current is now shut off?

Try the other end of the nail. Try both ends on the compass needle.

Is this nail a magnet with north and south poles?

Does it remain magnetized when the current is off?

Unless the iron nail is very soft it will hold some of this magnetism.

Such a magnet, or solenoid surrounding a nail or other piece of iron, is called an electromagnet.

A piece of gas pipe, or a bundle made of pieces of soft iron wire of equal length and wrapped together by the wire, makes a good core in place of the nail.

Problem 16: Why has the nail strong magnetism when in the coil with current passing through, and none, or very little, when there is no current in the coil?

Pupils soon draw the inference that the magnetic field about the wire, when the current passes, enters the nail and magnetizes it.

Problem 17: Why use covered or insulated wire in making solenoids and electromagnets?

Pupils wind bare copper wire closely on a pencil so that the separate coils touch, and test with nail as before. Does it work as well?

Does the current go around each coil or cut across from one to the other?

If the latter is the case, is the circuit for the current shorter than or the same length as before?

If the current cuts across, it is called "short-circuiting."

Why is wire covered? Why use covered wire then for apparatus work?

Problem 18: Can an old bar magnet be made stronger by winding wire around it and sending a current through the wire?

Pupils try it, testing the magnet before and after the current is sent around it.

Can you make a new bar magnet by sending a current around a bar of hard steel?

Secure some hard steel from a blacksmith or a machine-shop and try it.

How then can bar magnets be made or magnetized?

Problem 19: How can a stronger electromagnet be made?

Pupils devise means, or the teacher leads them to wind more wire, another layer, on the electromagnet just made, and test it. Will it lift more tacks, nails, or heavier pieces of iron than before? Why?

Now add one or two more cells, so as to have a stronger current, and test again.

In what way, or ways, then, is the magnet made stronger?

Problem 20: How can the magnetic field of one pole of an electromagnet be shown?

Pupils stand the electromagnet on end, place sheet of cardboard on top, sprinkle filings on it, and tap gently while current is on.

Draw a picture of it in notebook.

Problem 21: Is the horseshoe-shaped electromagnet of the same strength as the straight one?

Pupils wind another nail, or bundle of six or eight wires, with same amount of wire as used in problem 15, putting nearly all the wire equally on the ends for about two inches, and very little wire in the middle.

Now carefully bend it all into a horseshoe shape without injuring the insulation. See Fig. 7, *A* and *B*. The bending may be done before winding the wire.

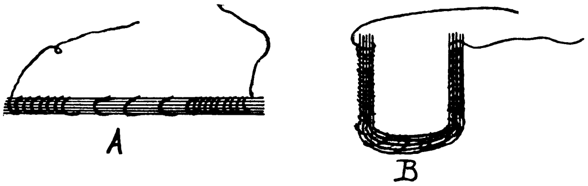

Fig. 7.—Electromagnets

See how much iron can be lifted by one end of the straight magnet and then lift as much as possible on the poles of the U-shaped magnet. Compare the strengths.

Test each pole of the U-shaped magnet by causing each in turn to approach the same end of a compass needle. Are the poles alike or different? What makes them so? (One pole should be north, the other south. If both poles are alike there has been some mistake in the winding.)

Do the windings on the poles of the horseshoe magnet seem to be in the same or in the opposite direction?

Recall the experiment showing the magnetic field around a wire (problem 13). Why then are the poles of the horseshoe magnet different?

Application of the U-shaped electromagnets: Bells and buzzers (review bell and note how it works), telegraph instruments, telephone receiver, arc lights, front-door latches in apartments, handling and shipping iron or iron products, mining iron ore, drawing steel from the eye in accidents, etc.

LESSONS ON THE TELEGRAPH INSTRUMENT

The use of the electromagnet in the telegraph instrument can be demonstrated easily by the pupils if they construct a simple instrument and use the magnets they made.

Problem 22: How has the electromagnet made possible the telegraph instrument?

Pupils fasten, with double-pointed tacks, the U-shaped magnet (*M*) to a block, 4×8 inches, two inches from one end. Support over the magnet a light stick 10 inches long (*A*) with a cross-piece of sheet iron (*I*), this iron to be just above the poles of the magnet. The stick is supported and pivoted on a piece of sheet metal at *P*. Make a push button on the block for a key (*K*), or use the push button already made. See Fig. 8.

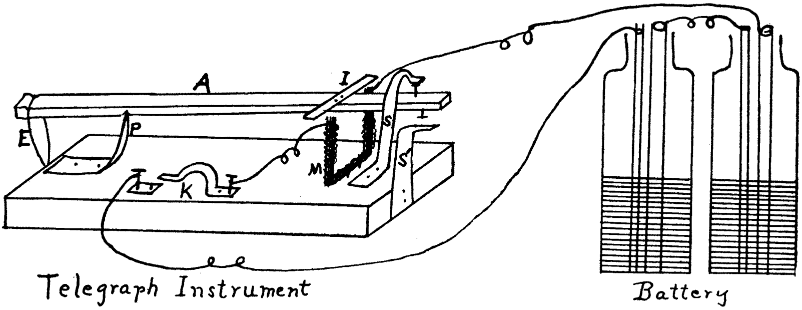

FIG. 8

The sounder consists of the stick (*A*) and two pieces of metal (*S* and *S'*) between which the stick vibrates. The narrow strip *S* curves up and over the stick, so that a small nail or tack in the stick strikes *S* and prevents the elastic band *E* from lifting the iron cross-bar on the stick too high above the magnet. Similarly the narrow strip *S'* prevents the stick from being drawn down far enough for the iron cross-bar to touch the magnet because of the tack in the stick just above *S'*. Allow the cross-bar to come as near the magnet as it can without actually touching it. One end of the wire from the magnet is connected to the push button, or key as it is called here, and the other end is attached to the cell. Another wire connects the cell to the other end of the push button.

The elastic band is so adjusted that it just barely lifts the stick and holds it against *S*. If the elastic is too tight or too strong, the magnet cannot pull the stick down. When the key is closed so that the current magnetizes the magnet, the iron cross-bar is attracted and pulled down until *S′* is struck by the tack on the under side of the stick. When the key is released, causing the magnet to lose its magnetism, the cross-bar is no longer attracted, and the elastic band raises the stick quickly until *S* is struck by the upper tack.

After the pupils can work such a telegraph instrument (our children always succeed after a little practice), two of them may connect their instruments with wire a few feet long, and send messages to each other. One pupil may take his instrument into the corridor, passing the wires under the door, and telegraph to his partner in the room. Either Morse's or the International code may be used. Our pupils often take these instruments home, and work them between houses if close together, or make a second instrument and telegraph from room to room.

Many other lessons in electricity are similarly given, as well as lessons in other phases of physical science.

A keen interest is aroused among both boys and girls by experimental work such as is outlined in this article, and one important result is that many of the children carry their interest in the science work to the home and continue it there.

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